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Neutral detergent fibre in forages preferred by African elephant (*L. africana*) in Rimoi Game Reserve, Kenya

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Abstract
Grass and browse have their relative advantages and disadvantages. For grass, intake rates are higher (it is easier to harvest and handle), it is lower in toxins and when its nutrient content is high, its fibre content is low (Lindsay, 1994), it also provides a return per unit time feeding that is higher than browse. It may, however, lack certain essential key nutrients and when it matures its nutrient content becomes very low. Browse offers generally higher levels and diversity of nutrients, but toxin and lignin levels are also higher. The tendency of elephants to shift from consuming mainly grass in the wet season to mostly browse in the dry season has been noted by many researchers (Santra *et al*., (2008); Lindsay, (1994)) [8]. Elephants can fulfil energy requirements from either browse or grass, depending on availability and quality, and switch to consuming crops whenever their forage sources are insecure, as grass availability is highly seasonal. Despite the attractiveness of crops to elephants, Osborn (2004) observed that elephants did not immediately leave protected areas when crops planted along the boundary were mature, which suggests that crop raiding could not be linked to the availability of crops, and thus this behaviour could be related to the quality and availability of wild foods. Hence it is important to establish the particular plant species which elephants eat in the wild, as the availability of these species could diminish the temptation to begin crop raiding. This paper presents findings of an investigative study on Neutral Detergent Fiber in Forages Preferred by African elephant (*L. africana*) in Rimoi Game Reserve, Kenya.

Keywords: Neutral Detergent Fiber, Forages, *L. Africana*, Rimoi Game Reserve

1. Introduction

Field observations have highlighted elephant-induced changes in community structure as palatable abundant tree species are selectively reduced (Tafangenyasha, 1997) and savannas become dominated by woody species which are unpalatable or disturbance-tolerant (Ben-Shahar, 1996) [2]. Lindsay (1994) [8] concludes that after 'a long and rather pointless debate', elephants are recognized as being both browsers and grazers and can fulfil energy requirements from either browse or grass, depending on availability and quality.

Elephants demonstrate distinct dietary preferences for particular species (e.g. marula *Sclerocarya birrea)* (Duffy *et al.*, 2002) [5] while avoiding others such as latex bearing *Euphorbia candelabrum*. It is generally assumed that in the absence of hunting/poaching, habitats with high animal densities (i.e. highly selected habitats) is of high quality, and low densities indicate low quality habitat. Animal populations respond positively to the availability of highly selected habitat types (Railsback *et al*., 2003) [12].

The impact of elephants on woody vegetation has led to concern about possible extirpation of plant species and of animal species whose persistence is dependent on forest or woodland habitat (Lombard *et al*., 2001). The influence of large body size on foraging ecology has the potential to affect the success of some woody species and possibly lead to extirpation of some preferred species (O'Connor *et. al*., 2007) [10]. The percentage of browse in the diet of an elephant is high during the late-dry season and drops off rapidly in the wet season (Osborn, 2004) [11].

Elephants selectively suppress the regeneration of desirable species when they occur in gaps created by falling trees, as they preferentially forage on their saplings (Smallie and O'Connor, 2000) [10]. *Acacia tortilis* is easily killed by moderate to high debarking or branch removal (Page, 1995). Selective feeding by mammalian herbivores on the more palatable woody species can result in domination of the vegetation by the chemically defended woody species (Bryant *et al.*, 1992) [3].

Due to the constant hedging of preferred species, an area heavily foraged by elephants will show a change in composition with an increase in stem density of less preferred species (Holdo, 2003) [7].

L. africana are known to migrate according to vegetation changes (Vanleeuwe & Gautier-Hion, 1998) [19]. The proximate factor that influences the decision to consume or reject a plant is the palatability of the item as conveyed to the herbivore through the senses of smell, taste, sight and touch. The selection of dietary items obviously depends to a large degree on what is available. In the processing of consuming an ideal diet from a natural environment, an elephant has to select from a changing mosaic of different plant species, phenological stages, structural types, chemical compositions, relative or absolute abundances and dispersion patterns (Sukumar, 2003) [17]. On a daily scale, intake rates are limited by digestion and excretion, and the amount of time invested for foraging. On a finer scale, consumption rates are influenced by the morphological properties and spatial distribution of plants (Shipley *et al.*, 1994) [14].

In India, elephants were observed to be feeding on wood and bark of *Acacia catechu* and bark from *Bombax ceiba* (Stenheim *et al.*, 2005). This was also confirmed by large, easily identifiable remnants in the fresh elephant dung, and signs of debarking on a number of these trees. In the Cat Tien National Park, Vietnam, elephants fed on at least 24 species of plants, both wild and cultivated. Of these, stems of 11 species, roots of 7, fruits of 4, and bark of 2 were eaten (Varma *et al.*, 2008) [20]. Supporting tissues such as stems, twigs, wood, roots and bark tend to be high in indigestible fibre, while fruits contain stores of soluble carbohydrates and leaves contain photosynthetic enzymes and are high in protein and minerals.

Digestion inhibitors consist of fibres and tannin. Fibre (often measured as Acid Detergent Fibre (ADF) is a major deterrent in food selection. The findings of Osborn (2004) [11] explains that the fibre content of grass increases and its moisture content drops as it ages, causing increased wear on teeth and a decline in digestive efficiency. When the fibre content is high and the protein content is low, there is decrease in the digestibility of protein (Osborn, 2004) [11]. Therefore the motivation or 'trigger' for crop raiding during any particular wet season may be a decline in the quality of wild grasses as the dry season approaches.

Several theories have been proposed suggesting that it is a consequence of physiological changes in the elephants and the vegetation. The factors underlying differences in species utilization have not been investigated (Holdo, 2003) [7]. Riparian habitats serve as key habitats for elephant by providing forage of adequate quality at the height of the dry season. The fibrous bark of *A. elatior* has a high tensile strength and tends to be ripped off in strips by the elephants.

Foley (2002) noted that the most severely damaged trees are the ones for which elephants have developed a predilection; consequently elephants seek out these trees until they become completely girdled and die within two years. Elephants in East Africa prefer grasses in the wet season turning to browse in the dry season when grass has withered (Holdo, 2003) [7]. The crude protein and fibre content in the browse fluctuates less than that of grass (Osborn 2004) [11]. Woody parts dominate the diet in dry season but leaves and shrubs are eaten throughout the year (Holdo, 2003) [7].

When green grass is less available during drought years, elephants are forced to increase consumption of bark earlier in the season when they are relatively the most palatable (Styles and Skinner, 2000). This results in increased impact on woody plants (Osborn, 2004) [11]. Jetz *et al.*, 2004 argued that elephants are dentally specialized towards grass feeding but because of changes in the grass' seasonal availability; they must be able to switch to alternate foods such as browse. Despite its higher lignin levels, browse offers higher levels and diversity of nutrients (Sukumar, 2003) [17]. Large-bodied herbivorous mammals survive on food of lower quality owing to their higher absolute metabolic needs, higher digestive efficiency, and lower specific metabolic rate (Belovsky, 1997). Edaphic factors influence diet quality since plants derive nutrients from the soil (Scholes and Walker, 1993).

1.1 Study Area

This study was done in Rimoi Game Reserve and Conservation Area (RGRCA) situated in Elgeyo-Marakwet County. Rimoi Game Reserve is situated in the Kerio valley floor in the Keiyo/Baringo boundary. It is situated between longitudes 35^0 30' and 35^0 40' East and latitude 0 ^{0} 40'and 0°50' North (Figure 1).

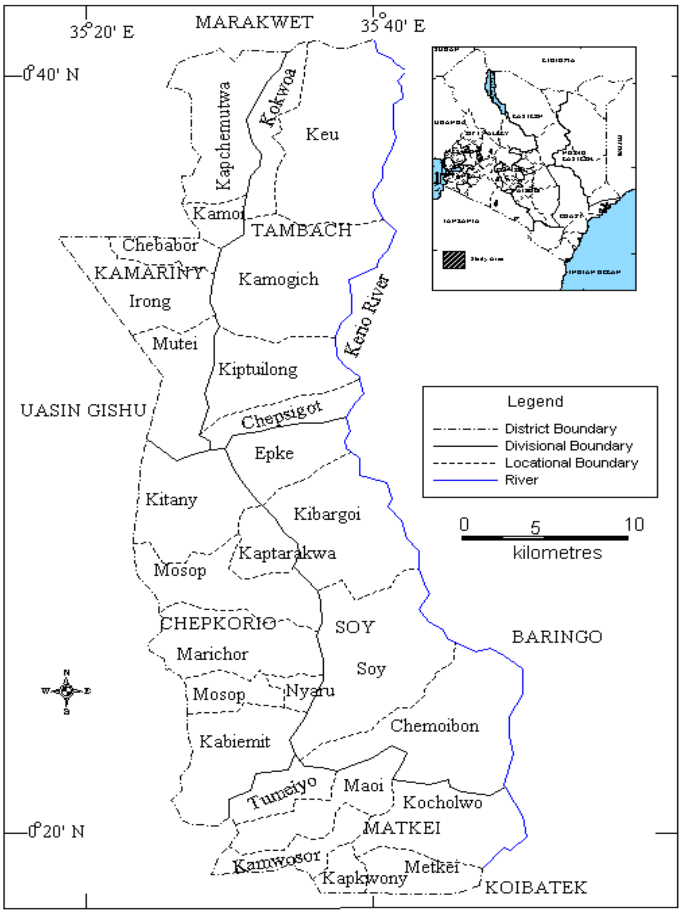

Fig 1: Study area

1.2 Data Collection

Forage preference was deduced from recent feeding trails of the African elephant (*L. africana*). Those plants showing signs of recent elephant browsing/grazing were picked, identified and tallied. The data on preferred forages by elephants were obtained by making a systematic record of the feeding behaviour. Their diet was deduced from records of plants which showed obvious signs of recent elephant use.

Debarked, browsed or grazed vegetation were picked with the use of a secateur. For each sampled tree or vegetation, areas showing signs of feeding like the leaves or bark samples were taken at browsing level for nutrient analysis. The picking was done for three hours every two days a week from 7.00 am. Picking was done at the onset of the planting season (start of wet season), harvesting season and dry season.

Each of the collected plant was identified /tagged, tallied and air dried in the field inside a brown 'sugar paper bag' and later transported to the laboratory (at Tea Research Foundation, Kericho and Kenya Agricultural Research Institute, Muguga) for analysis of nutritional content. The sampling regime was that three samples of each plant species in a season were collected and analyzed. Twenty five plants were considered for nutrient analysis (Samples of *Acacia tortilis* and *Ficus spp*. bark were also taken), which was composed of nineteen wild forages and six major crops raided. The start of the planting season was in Apri-May, harvest season was in July-August; and start of dry season was in October-November.

1.3 Data Analysis

For the plant nutrient content nutrients, laboratory analysis was done at the tea research foundation of Kenya (Kericho) and at the Kenya agricultural research institute (Muguga). Eighty one samples were collected from different plant species. The elements analyzed for were Ca, Mg, Mn, N, K, P, Cu, and Na. Two bark (*A. tortilis* & *Ficus* species) samples were also analysed. The procedure of Chapman and Pratt (1961) with slight modification was used in the analysis of micro and macro nutrients. However, nitrogen was analyzed using Kjehldal methods (N × 6.25). Neutral detergent fiber analysis was also done. All the methods were done according to the procedures detailed in American Public Health Association (APHA, 1998). Once all the survey data had been collected, they were coded in Statistical Package for Social Sciences (SPSS ver. 17.0). All the data were analysed by descriptive statistical analysis.

In the survey and habitat change study chi square analysis was carried out to see whether there were any significant differences. In the analysis of nutrients, both analysis of variance and multiple regressions were used to obtain the relationship between preference of forage and the nutrients. The nutrients were subjected to ANOVA to examine the extent of variation within the season so as to make a decision on their influence on foraging preference

1.4 Results

The concentration of Neutral Detergent Fiber (NDF) in wild forages was also determined (Figure 2). The differences in NDF levels in plants were significant (ANOVA, F = 18.137, df = 20, p = 0.0025). High NDF were shown by *A. tortilis* bark (B) (84.5 %), *Cynodon dactylon* (75.4 %) and *C. pycnothrix* (72.96 %).

Fig 2: Browsed and debarked *Acacia tortilis* by *L. africana african* in Rimoi Conservation Area

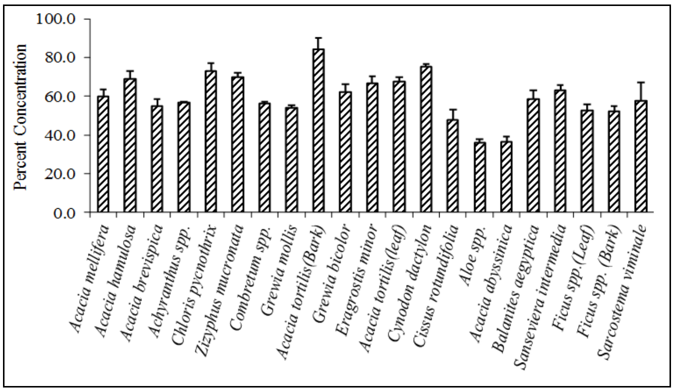

Fig 2: Percentage concentration of NDF in wild forage browsed/grazed by *L. africana africana* in Rimoi Conservation Area

Results showed differences in the concentration of NDF in the raided crops by *L. africana* a*fricana* in Rimoi Conservation Area (Figure 3). There were significant differences in the levels of NDF among raided crops (ANOVA, F = 19.009, df = 5, p = 0.025). Maize (65.43 %), sorghum (74.4 %) and cowpea (63.17 %) contained significantly higher concentration of NDF than millet (52.81 %), and green grams (26.4 %) which had low concentration of this element.

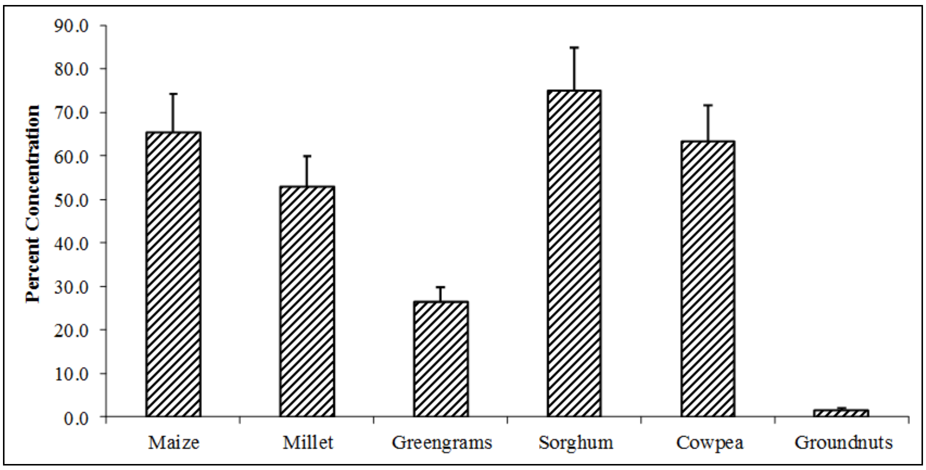

Fig 3: Percent concentration (%) of NDF in raided crops by *L. africana* a*fricana* in Rimoi Game Reserve and Conservation Area

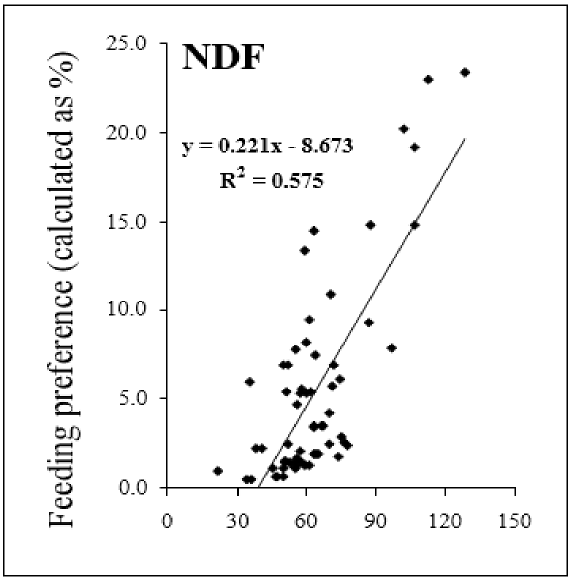

Fig 4: Nutrient contents in the wild forages

Regression plots showing the relationships between the food preference and levels of nutrient elements in forages preferred by *L. africana africana* in Rimoi Conservation Area. The regression fit using linear regression and the regression coefficients are also indicated in the figures. Results showed that, the relationships between the feeding preference and element concentrations in the food crops were highly influenced by NDF as shown by the model (Table 1).

Table 1: Relative contribution of nine nutrients to the regression model of the feeding preference by *L. africana africana* on the wild forages in Rimoi Conservation Area

	Coefficients	Contribution to the model	Standard Error	P-value
Intercept	-7.5354	-	1.3487	0.0000
N	1.4692	12.7977	0.3229	0.0000
P	0.7624	2.4338	2.6964	0.7784
K	-0.4673	1.4917	0.3682	0.2097
Ca	0.5532	13.9275	0.3412	0.1106
Mg	4.0311	12.8682	0.8583	0.0000
Mn	34.6568	29.5563	18.2922	0.0634
Na	-0.0842	0.2688	0.4603	0.8555
Cu	0.2163	15.5545	0.0978	0.0312
NDF	0.0913	11.1017	0.0173	0.0000

2. Discussion

The high Neutral Detergent Fibre (NDF) values exhibited generally indicate that there would be low intake of these forages by elephants. NDF as one of the nutrients shows to contribute to the forage preference by elephants and probably its behaviour. As the forage moisture content drops it becomes more fibrous resulting in a lowered digestive efficiency which will bring about an increase in consumption of available food. The study showed that NDF was high in both crops and preferred wild vegetation. Crops showed a high mean fibre content, though they showed variations over the seasons, which are consistent with studies carried out by Chapman *et al*., (2003) [4]. In this study, NDF did not fluctuate greatly from season to season in the wild vegetation indicating that the nutritional value did not change greatly, unlike crops which showed a lower NDF in the month of April, August and October.

3. Conclusion

The nutrient elements in preferred wild forages varied. *Acacia tortilis* (Bark) showed high NDF, though there was variation over the season, which were consistent with findings of Chapman *et al*., (2003) [4]. The authority should exercise more caution due to increased area of movement by elephants when there is disappearance of acacia plants which are rich in nutrients, for example *Acacia tortilis* (bark) has both high NDF and Ca, and its disappearance has great impacts to elephant behaviour

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